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FOR: LIQTTID CRYSTAL DTSPLAY
DEVICE AND METHOD OF
MANUFACTURING THE SAME

DECLARATION

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SIR:

I, Hiroshi Yamamoto, having a place of business at 8th Floor, Sumitomo-Hamamatsucho Building, 18-6, Hamamatsucho 1-chome, Minato-ku, Tokyo, 100-0013 Japan, solemnly and sincerely declare;

That I have a thorough knowledge of Japanese and English languages; and

That the attached pages contain a correct translation into English of the specification of Japanese Application No. 2002-219888 filed July 29, 2002, in the Japanese Patent Office in the name of Kabushiki Kaisha Toshiba.

Signed this 7th day of March, 2005.

H. Yamamoto ______ March 7, 2005
Date

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[NAME OF DOCUMENT] SPECIFICATION

[TITLE OF THE INVENTION] Liquid crystal display device and method of manufacturing the same

[CLAIMS]

[Claim 1]

A liquid crystal display device including thin film transistors formed on a substrate, and an insulation film having first and second regions which are different in thickness from each other and formed on said thin film transistors, characterized in that a light shielding film is provided at portions underneath boundaries of said first and second regions.

[Claim 2]

The liquid crystal display device according to Claim 1, characterized in that transparent and reflective electrode films are further formed on said first and second regions, respectively.

[Claim 3]

The liquid crystal display device according to Claim 1 or 2, characterized in that said light shielding film is made of the same material as said thin film transistors.

[Claim 4]

A method of manufacturing a liquid crystal display device characterized in the steps of forming a light shielding film on a substrate, forming a photosensitive insulation film on said substrate and said light shielding film, and exposing said photosensitive insulation film to position said light shielding film underneath boundaries of pattern and non-pattern regions of said

insulation film.

[Claim 5]

The method of manufacturing a liquid crystal display device according to Claim 4, characterized in that thin film transistors are made of the same material as said light shielding film at the step of forming said light shielding film.

[Claim 6]

A method of manufacturing a liquid crystal display device characterized in the steps of forming any one of reflective, light shielding or diffusing films on a back surface of a substrate, forming a photosensitive insulation film on a front surface of said substrate, and exposing pattern regions of said insulation film.

[DETAILED EXPLANATION OF THE INVENTION]

[0001]

[FIELD OF THE INVENTION]

This invention generally relates to a liquid crystal display device and a method of manufacturing the same and, more particularly, to a liquid crystal display device requiring highly accurate dimensions of a pattern formed by the exposure of a photoresist material and a method of manufacturing such liquid crystal display device.

[0002]

[PRIOR ART]

A thin film transistor (TFT) array substrate used for a half-transparent type liquid crystal display device is provided with reflective and transparent display portions. The reflective display

portion is generally made of thin film transistors formed on the TFT array substrate, an insulation film covering the thin film transistors and reflective electrode films formed on the insulation film while the transparent display portion is, on the other hand, made of transparent electrode films formed on the insulation film in place of the reflective films.

[0003]

The insulation film of the reflective display portion is intentionally designed to be different in thickness from that of the transparent display portion to increase the reflection coefficient and transmittance of the reflective and transparent display portions, respectively. In addition, when the TFT array substrate is put together with a counter substrate, the cell gaps defined in the reflective and transparent display portions are configured to be optimal, respectively. In order to adjust such thickness difference between the reflective and transparent display portions, a photoresist resin is coated on both the reflective and transparent display portions of the TFT array substrate, the transparent display portion is subjected to an optical exposure treatment, and both reflective and transparent display portions are then developed and post-baked.

[0004]

Since a photoresist resin with high transmittance is, however, used for the insulation film, the photoresist resin is subjected to reflecting light from an exposure stage during the exposure treatment.

[0005]

As shown in Fig. 5, optical exposure stage 210 is provided with holes 212 through which air is sucked to set a TFT array substrate on exposure stage 210 or the TFT array substrate is pushed out for removal, and plates 214. Although holes 212 do not reflect incident light, plates 214 reflect the same. Thus, portions of insulation film 128 corresponding to holes 212 receive incident light passing through photomask 208. The other portions of insulation film 128 corresponding to plates 214, however, receive not only incident light passing through photomask 208 but also reflecting light from plates 214. Since pattern dimensions depend on receiving quantity of light, patterns of portions positioned above holes 212 are small in width but those of the portions positioned above plates 214 are wide in width. Such pattern different widths cause visibly uneven brightness of images displayed by an liquid crystal display device.

[0006]

The present invention is made to overcome such defects. It is, accordingly, an object of the present invention to prevent the occurrence of visibly uneven brightness caused by pattern width differences resulting from receiving quantity of light reflecting from an optical exposure stage.

[0007]

The present invention has been made to solve the problem set forth above. The first feature is to provide a liquid crystal display device comprises thin film transistors formed on a substrate, an insulation film having first and second regions which are different

in thickness from each other and formed on the thin film transistors, and a light shielding film provided at portions underneath boundaries of the first and second regions. Further, transparent and reflective electrode films are preferably formed on the first and second regions, respectively.

[0008]

According to this structure, light reflecting from the exposure stage to portions underneath the first and second regions or those underneath transparent and reflective regions provided for transparent and reflective electrode films, respectively, is prevented from arriving at the insulation film. Further, even though the exposure stage has surface portions with different reflection coefficients, the insulation film is also prevented from decreasing its manufactured size accuracy.

[0009]

In addition, the insulation film is preferably made of the same material as the thin film transistors. In the case that the insulation film and the thin film transistors are made of the same material, those components can be formed in the same step of a manufacturing process.

[0010]

The second feature of the present invention is a method of manufacturing an liquid crystal display device which includes the steps of forming a light shielding film with first and second regions on a substrate, forming a photosensitive insulation film on the light shielding film, and carrying out expose to position the light

shielding film underneath boundaries of pattern and non-pattern regions of the insulation film.

[0011]

According to this method, light reflecting from the exposure stage to portions underneath the first and second regions or those underneath transparent and reflective regions provided for transparent and reflective electrode films, respectively, is prevented from arriving at the insulation film. Further, even though the exposure stage has surface portions with different reflection coefficients, the insulation film is also prevented from decreasing its manufactured size accuracy.

[0012]

In addition, the insulation film is preferably made of the same material as the thin film transistors. In the case that the insulation film and the thin film transistors are made of the same material, those components can be formed in the same step of a manufacturing process.

[0013]

The third feature of the present invention is a method of manufacturing a liquid crystal display device which includes the steps of forming any one of reflective, light shielding or diffusing films on a back surface of a substrate, forming a photosensitive insulation film on a front surface of the substrate, and exposing a pattern region of the insulation film.

[0014]

According to the method, light passing through the substrate at the

exposing step is fully reflected from the reflective films on the back surface of the substrate, is not reflected by the light shielding film at all, or is reflected uniformly from the entire region of the substrate surface on which the light diffusing films are formed Thus, even though the exposure stage has surface portions with different reflection coefficients, the insulation film is prevented from decreasing its manufactured size accuracy.

[0015]

[EMBODIMENTS OF THE INVENTION]

Embodiments of the present invention will be explained below with reference to the attached drawings. It should be noted that the present invention is not limited to the embodiments but covers their equivalents. Throughout the attached drawings, similar or same reference numerals show similar, equivalent or same components. The drawings, however, are shown schematically for the purpose of explanation so that their components are not necessarily the same in shape or dimension as actual ones. In other words, concrete shapes or dimensions of the components should be considered as described in these specifications, not in view of the ones shown in the drawings. Further, some components shown in the drawings may be different in dimension or ratio from each other.

[0016]

(FIRST EMBODIMENT)

Fig. 1 shows a schematically sectional view of a liquid crystal display device in accordance with the first embodiment of the

present invention. As shown in Fig. 1, the liquid crystal display device includes thin film transistor (TFT) array substrate 120 and color filter substrate 140. TFT array and color filter substrates 120 and 140 are provided opposite to each other, define a predetermined gap supported by spacers 160, and are put together by a sealing material around their peripheral portions. A liquid crystal material injected into the gap becomes liquid crystal layer 180.

[0017]

TFT array substrate 120 includes transparent glass plate 122, and TFT electrodes 124 and light shielding films 126 formed on glass plate 122. TFT electrodes 124 and light shielding films 126 are covered with insulation film 128. Further, insulation film 128 is coated with transparent electrodes 130 made of an indium-tin-oxide (ITO) film and reflective electrodes 132 made of a metal film. In order to widen a viewing field for reflecting light, reflective electrodes 132 are provided with uneven portions.

[0018]

Light shielding films 126 are made of such materials that sufficiently prevent light, which passes through regions of the transparent electrode and reflects from an optical exposure stage, from arriving at regions of reflective electrodes 132. They are preferably of the same materials as those of TFT electrodes 124, more particularly, such as molybdenum, so that light shielding films 126 may be formed in the same process as TFT electrodes 124.

[0019]

Light shielding films 126 are disposed at locations underneath the

boundary regions between transparent and reflective regions 1300 and 1320 to be set forth below with reference to Fig. 3. The thickness and width of light shielding films 126 are configured to substantially prevent light, which passes through regions of the transparent electrodes and reflects from the exposure stage, from arriving at regions of reflective electrodes 132. In other words, the thickness and width of light shielding films 126 are determined in accordance with a material and light beam radiating conditions, such as light wavelength, frequency, and radiating angle and duration. For example, where such a material and radiating energy are molybdenum and 300mJ/cm2, respectively, light shielding films 126 are 0.3 μm to 10 μm in thickness and preferably about 6 μm in width.

[0020]

Fig. 2 shows a schematic plan view of a layout of the liquid crystal display device shown in Fig. 1. As shown in Fig. 2, signal lines 202 cross over scanning lines 204 to form a matrix. Transparent and reflective regions 1300 and 1320 are provided in each element (pixel) of the matrix. Auxiliary capacitor lines 206 are disposed in parallel with scanning lines 204. As described above, light shielding films 126 are provided at the locations underneath the boundary regions between transparent and reflective regions 1300 and 1320. Thus, light shielding films 126 are shown in locations between transparent and reflective regions 1300 and 1320 in Fig. 2. In short, light shielding films 126 are provided to surround transparent regions 1300.

[0021]

On the other hand, as shown in Fig. 1, color filter substrate 140 includes color photoresist films 144R (red), 144G (green) and 144B (blue) formed on the surface of transparent glass plate 142, transparent electrode 146 is formed on the surface of color photoresist 144, and an alignment film which is not shown is formed on cover the surface of transparent electrode 146.

[0022]

Further, in the liquid crystal display device shown in Fig. 1, an optical path for light to pass through liquid crystal layer 180 at the reflective display mode is different in length from that at the transparent display mode. In other words, when the liquid crystal display device carries out the transparent display mode, light from rear light source 190 passes through liquid crystal layer 180 only once. When the liquid crystal display device carries out the reflective display mode, however, incident light from color photoresist film 144 passes through liquid crystal layer 180 and light reflecting from reflective electrode 132 passes through liquid crystal layer 180 again. Where the height of reflective electrode 132 is the same as that of transparent electrode 130, the optical length of the reflecting light is much longer than that of the light only passing through liquid crystal layer 180. Thus, in order to obtain optimum optical characteristics in both transparent and reflective display modes, it is necessary to carry out the optimum design of the cell gaps on reflective and transparent electrodes 132 and 130, respectively. As shown in Fig. 1, insulation film 128 under

reflective electrode 132 is thicker in thickness than insulation film 128 under transparent electrode 130 to adjust the optical length for the ambient light to pass through liquid crystal layer 180 and that for the light from the rear light source to pass through liquid crystal layer 180. For such adjustment of the optical lengths, optical exposure is carried out only for the regions of the insulation film on which the transparent electrodes are formed and, then, development and post baking processes are applied to them.

[0023]

A method of manufacturing the liquid crystal display device of the first embodiment will be explained with reference to Figs. 3(A)-3(C). A primary feature of the method of manufacturing the liquid crystal display device is that light shielding films 126 are formed on glass plate 122 as shown in Fig. 3(A), photosensitive insulation film 128 is further coated on light shielding films 126 and glass plate 122 as shown in Fig. 3(B) and optical energy radiation is carried out only for the transparent regions of insulation films 128 by using photomask 208 as shown in Fig. 3(C).

[0024]

As shown in Fig. 3(C), where optical exposure stage 210 has holes 212 through which air is sucked to set the substrate on optical exposure stage 210, the radiating light travels to the lower side of exposure stage 210 without reflection. Light reflecting from plates 214, on the other hand, travels in glass plate 122 again but does not arrive at insulation film 128. Thus, the portions of the insulation film positioned above both holes 212 and plates 214 receive

substantially the same quantity of light.

[0025]

A comparison test has been made for each of the following liquid crystal display devices: (1) the first embodiment liquid crystal display device provided with patterns of the thick and thin portions of the insulation film underneath the transparent and reflective electrodes, respectively, and light shielding films 126 formed around transparent regions 1300, and (2) a prior art liquid crystal display device provided with patterns of the thick and thin portions of the insulation films underneath the transparent and reflective electrodes, respectively, but no light shielding films. As a result, 70% uneven display has been visibly recognized for the prior art liquid crystal display device but no uneven display has been visibly recognized for the first embodiment liquid crystal display device.

[0026]

Since, as described above with respect to the first embodiment, the receiving quantity of light is substantially equal for both portions of insulation film 128 positioned above holes 212 and plates 214, neither the patterns positioned above holes 212 become narrow in width nor those above plates 214 become wide in width. Such structure does not bring about an uneven display.

[0027]

For the convenience of explanation, TFT electrodes 124 are omitted from the drawings of Figs. 3(A)-3(C). In order to reduce manufacturing steps, time and costs, however, it is preferable to form TFT electrodes 124 at the same time with the same material

as light shielding films 126.

[0028]

(SECOND EMBODIMENT)

The liquid crystal display device according the first embodiment of the present invention prevents an uneven display due to different reflection coefficients at exposure stage 210 by means of light shielding films 126 provided at predetermined locations between glass plate 122 and insulation film 128. An liquid crystal display device in accordance with a second embodiment of the present invention is, however, provided with a reflective film coated on the back surface of its TFT array substrate to avoid such an uneven display.

[0029]

A method of manufacturing a liquid crystal display device according to the second embodiment will be explained below with reference to Figs. 4(A)-4(C). A primary feature of the second embodiment manufacturing method is that a reflective film 404 is formed on glass plate 402 as shown in Fig. 4(A), photosensitive insulation film 406 is formed on the glass plate as shown in Fig. 4(B), and energy radiation is selectively carried out for transparent regions of insulation film 406 by using photomask 420 as shown in Fig. 4(C).

[0030]

Now, the second embodiment will be described below concretely. Reflective chromium film 404 is uniformly coated on the back surface of 400mm x 500 mm glass plate 402 (Fig. 4(A)). The film

forming and patterning steps similar to those in an ordinary process to form thin film transistors are repeated to form thin film transistors, electrodes, wirings and pixel electrodes. Such thin film transistors, electrodes, wirings and pixel electrodes are not shown in Figs. 4(A)-4(C).

[0031]

A photosensitive organic material is then coated on glass plate 402 on which the thin film transistors, etc. are provided, so that insulation film 406 is formed (Fig. 4(B)). Glass plate 402 provided with reflective and insulation films 404 and 406 on the front and back surfaces, respectively, is loaded on optical exposure stage 410. Exposure stage 410 is provided with holes 412 through which air is sucked to place glass plate 402 on exposure stage 410 or glass plate 402 is pushed out for removal. Light from light source 422 is radiated only through transparent portions with photomask 420. The radiated light does not pass through reflective film 404 but reflects from reflective film 404. Such reflecting light passes through glass plate 402 and insulation film 406 again and returns to photomask 420. Thus, regardless of places to which light is radiated, i.e., whether the places are positioned above holes 412 or not, the light received by insulation film 406 is substantially the same in quantity. Dimensions or shapes of uneven portions of insulation film 406 formed after the exposure and development treatments are substantially the same whether the transparent regions are positioned above the holes or not. As a result, an uneven display is not visually recognized on the liquid crystal

display device.

[0032]

Instead of coating reflective film 404 on the back of glass plate 402, a light shielding film attached to the same obtains substantially the same effect. Also, a light diffusion film attached to the back of glass plate 402 obtains the same effect because, if the light shielding film 404 can prevent the light from traveling to exposure stage 410, the reflecting light arriving at insulation film 406 becomes nil or no different in quantity regardless of places above which holes 412 are positioned or not. Also, if the diffusion film diffuses the light traveling to exposure stage 410, the reflecting light arriving at insulation film 406 becomes nil or no different in quantity regardless of places above which holes 412 are positioned or not.

[0033]

After concave and convex portions are made on insulation film 406, reflective and transparent electrodes are formed on the concave and convex portions to define reflective and transparent regions, respectively. It is desirable to use ITO and molybdenum or aluminum films for the transparent and reflective electrodes, respectively. Further, it is also desirable to form much smaller convex and concave portions on the surface of the convex portions so that they diffuse the incident light to widen a viewing angle at the reflective display mode.

[0034]

With the structure described above, the total receiving quantity of

light at the portions positioned above holes 412 of exposure stage 410 is substantially the same as that at the portions positioned above absence of holes 412 of exposure stage 410. Thus, pattern sizes formed on insulation film 406 are not different whether such pattern is positioned above holes 412 of exposure stage 410 or not. An uneven display has not been visually recognized in the second embodiment liquid crystal display device, either.

[0035]

[EFFECT OF THE INVENTION]

According to the present invention, a photosensitive resin film can receive no or uniform light from an optical exposure stage even though an exposure stage includes surface portions with uneven reflection coefficients, so that it is possible to realize an liquid crystal display device without uneven brightness or displays.

[BRIEF DESCRIPTION OF THE DRAWINGS]

Fig. 1 shows a schematically sectional view of a liquid crystal display device in accordance with a first embodiment of the present invention.

Fig. 2 is a schematic plan view of a layout of the liquid crystal display device shown in Fig. 1.

Fig. 3 is drawings showing production steps of the liquid crystal display device in accordance with the first embodiment of the present invention.

Fig. 4 is drawings showing production steps of the liquid crystal display device in accordance with a second embodiment of the present invention.

Fig. 5 is a drawing to explain effects of reflecting light in an exposing step of a prior art liquid crystal display device.

[EXPLANATION OF REFERENCE NUMERALS]

120: TFT substrate, 122: glass substrate, 124: thin film transistors, 126: light shielding film, 128: insulation film, 130: transparent electrode, 132: reflective electrode

ABSTRACT OF THE INVENTION

[PROBLEM TO BE SOLVED]

A problem to be solved is to prevent the occurrence of uneven displays on a liquid crystal display device by enabling to form a highly precise pattern even though an exposure stage has portions with different reflection coefficients.

[SOLUTION]

A liquid crystal display device includes thin film transistors 124 formed on glass plate 122, and photosensitive insulation film 128 having transparent and reflective regions 1300 and 1320 which are different in thickness. Insulation film 128 includes. Light shielding films 126 are provided underneath boundaries of transparent and reflective regions 1300 and 1320.